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Using risk sharing contracts for supply chain risk mitigation: A buyer-supplier power and dependence perspective

Abstract:

The paper aims to understand buyer-supplier power and dependence scenarios following a risk sharing contract. The study develops a supply chain risk sharing contract to mitigate demand uncertainty and price volatility related risks in a globalised business environment. An integer programming model is developed and analysed following an automotive case study to generate insights into buyer-supplier relationships. Multiple buyer-supplier power and dependence scenarios are considered to reflect the possible leverages involved in the decision-making. The situational strength evaluated through buyer-supplier power and dependence illuminates the inherent complexity in contract negotiation. Thus there is an evident need to develop risk sharing contracts for mitigating global risks. The developed relationship framework and risk sharing contract model are expected to help SC managers in better understanding behavioural aspects during contract negotiations. The risk sharing contract model proposed here also contributes to a potentially novel perspective on existing theory in buyer-supplier power and dependence by providing a relational perspective on the dynamics of supply chain design and collaboration.

Keywords:

Buyer-Supplier Relationships, Risk Sharing Contracts, Power and Dependence, Supply Chain Risk Management

1. Introduction

The rise of global markets and therefore global competition has forced today's supply chains to change their risk management strategies. Risk mitigation is becoming a primary motive behind all contractual agreements and is believed to be beneficial for the complete supply chain network (Xiao and Yang, 2009). Flexibility in accommodating demand fluctuation and responsiveness to price volatility are two key requirements of current supply chain management practices. In order to manage uncertainties in demand and pricing, supply chains need to develop robust contractual mechanisms especially for highly configured

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products in automotive, aerospace, electronics and other heavy industries. Typically, Build-To-Order (BTO) or Make-To-Order (MTO) products are characterised by uncertain demand, long lead times and fluctuating purchase costs (Wang and Tsao, 2006). BTO or MTO approaches have been actively pursued by companies like Dell Computers, BMW, IBM, HP, and Compaq to manage varying patterns of demand (Ghiassi and Spera, 2003; Hsu and Wang, 2004; Gunasekaran and Ngai, 2005). Demand uncertainty incurs a risk cost to the supplier whereas price volatility incurs a risk cost to the buyer. Global markets with global competition magnify the risks of demand fluctuation and price volatility; such uncertainty means supply chains demand additional risk mitigation assurances through the use of different control mechanisms such as contracts or legal agreements (Laequddin et al., 2009).

Contractual negotiations with supply chain partners are vital to establish visibility and risk control through agreed contractual processes to manage fluctuations in demand and price volatility (Gunasekaran and Ngai, 2005). Supply chain contractual processes that address demand uncertainty like buyback, quantity flexibility, revenue sharing, profit sharing and full return have been discussed in the literature (e.g. Cachon and Lariviere, 2005; Emmons and Gilbert, 1998; Tsay and Lovejoy, 1999; Jeong, 2012). However, the area of supply chain contracts under price uncertainty (e.g. Li and Kouvelis, 1999) has attracted less academic attention. The Supply Chain (SC) contractual processes listed earlier all address improving the efficiency of a SC network, but do not usually actively address the risk mitigation. Supply chain contracts could offer robust strategies to increase SC resilience through mitigating uncertainties or risks in addition to making a SC more efficient (Tang, 2006).

Researchers often utilise the classic newsvendor problem when modelling supply chain contracts (e.g. Lariviere and Porteus, 2001; Lau et al., 2008; Cheng, 2011), but in this study the researchers' take a pragmatic approach, testing the SC risk sharing contract model in an industry setting. Supply chain contracts developed through the newsvendor problem are most commonly based on a risk neutrality assumption (Wang and Webster, 2009). However, in a stochastic market environment risks such as lost sales, delivery unreliability and obsolescence significantly affect all SC stakeholders. Relationship and situational strength (power) are key issues within any SC as stakeholders use power and dominance to define the rules of the collaborative partnership (Kehoe et al., 2007). Opportunistic behaviour, while making decisions, has a severe effect on SC and is receiving increasing attention in supply chain design (Craighead et al., 2007; Ellis et al., 2010; Sodhi et al., 2012). In the next section the literature

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is utilized to identify satisfaction level and dominance level as two parameters used to capture negotiating SC dynamics under conditions of buyer-supplier power and dependence.

In summary, through a risk sharing contract, this study attempts to illuminate the behavioural aspects of supplier and buyer that stem from the inevitability of issues of power and dependence in supply chain contract negotiations. Studies on flexibility contracts focusing on buyer's ordering behaviour, when faced with a static market demand are evident (e.g. Bassok and Anupindi, 2008; Lian and Deshmukh, 2009). Nonetheless, there exists a research gap in studying risk sharing contracts under dynamic market requirements that include a buyer-supplier relational perspective. Furthermore, there is limited literature on supply chain contracts under the combined effects of demand uncertainty and price volatility.

Following this introduction, section 2 reviews extant literature in two parts, firstly introducing work on supply chain risk and uncertainty, then narrowing down to assemble the arguments made in the literature for risk sharing contracts. A second section of literature review captures the views on power and dependence issues inherent in buyer-supplier relationships. Section 3 introduces a conceptual framework to define the objective and to limit the scope of the research to the area of buyer-supplier independence. Section 4 presents a risk sharing contract model, developed by formulating a mathematical problem in order to obtain the optimum contract quantity for mitigating the combined risk of demand fluctuation and price volatility in a SC. Section 5 analyses the risk sharing contract model, the results are compared with two different solution approaches to studying the situational strength of SC stakeholders. Finally, in section 6, conclusions, the importance of a risk sharing contract as a tool to mitigate supply chain disruption risk and the need for further research in this area is reiterated and additional managerial implications offered for those responsible for managing risks in a globalised economy.

2. Literature Review

2.1. Supply chain risk and uncertainty

Due to increasing globalisation, practitioners and researchers are paying more attention to Supply Chain Risk Management (SCRM) (Manuj and Mentzer, 2008; Ghadge et al., 2012). This heightened level of attention is evident from several literature reviews on supply chain risks and uncertainty (e.g. Natarajarathinam et al., 2009; Rao and Goldsby, 2009; Tang and

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Musa, 2010; Simangunsong et al., 2012; Sawik, 2016). It is a broad topic that encompasses various forms of supply chain risk, including financial and operational risks (Snyder et al., 2016). SCRM has become a modern challenge because of shorter product life cycles, increased uncertainties, etc. (Christopher and Lee, 2004). Furthermore, globalisation increases supply chain complexity and increases the impact of disruptions (Christopher and Towill, 2002) and general vulnerability to risks (e.g. globalisation related activities such as on-shoring, off-shoring, complex outsourcing, and increased mergers) (Bakshi and Kleindorfer, 2009). Yu and Goh (2014) investigate the twin effects of SC visibility and risk on SC performance. Tang (2006) highlights the necessity of new approaches to mitigate vulnerable risks and minimise potential losses.

Risk and uncertainty are two different terms that are often used interchangeably in the academic literature. However, risk can be measured unlike uncertainty (Knight, 1921). Several academic definitions of risk and uncertainty co-exist. Most theorists have defined risk as a negative outcome. Lowrance (1980) notes that, the term risk means the probability and impact of uncertain factors. Rowe (1980) defines risk as the probability of realizing negative consequences from uncertainties. Risk has been defined as a measure of the probability and severity of adverse effects (Claypool et al., 2014). From a supply chain perspective, risk is associated with the negative consequences of uncertainty within the SC or network (Christopher and Lee, 2004; Wagner and Bode, 2006). Supply chain risk has been defined as purely negative consequence within information, financial and material flows (Wagner and Bode, 2008). Supply chain risk sources are unpredictable variables within an organization, network or environment. These risks exist because of uncertainty about future risk events, which can appear at any point in time in the supply chain (Aqlan and Lam, 2016).

Risk mitigation and control strategies are classified into two approaches: proactive and reactive (Ghadge et al., 2013). Adopting an effective risk management strategy based on global supply chain environment is becoming increasingly challenging (Christopher and Towill, 2001; Manuj and Mentzer, 2008). Fahimnia et al. (2015) presents a systematic review of the quantitative and analytical models for managing SC risks. SC strategies like dual/multiple sourcing, postponement, Vendor-Managed Inventory, long-term contracts, supplier collaboration and development are being used not only to improve overall SC performance, but also as risk mitigation strategies as evidenced through the literature. Chen et al. (2013) presented a collaborative approach for the mitigation of SC operational risks by focusing on

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supply and demand risks. In a complex SC network there is an imperative to examine the flexibility and uncertainty to mitigate risks. Flexibility provides virtual capacity and is one of the most effective measures to mitigate supply chain risks (Aqlan et al., 2016). The benefits of flexibility to the buyer increase as uncertainty increases (Karakaya and Bakal, 2013). SC risk mitigation strategies should be amalgamated with the top managerial decision making processes to alleviate supply chain risks and improve the robustness of supply chains (Rajesh and Ravi, 2015). Borodin et al. (2016) provides an overview of the latest advances in the application of OR methodologies to handling uncertainty occurring in Supply chains.

2.1.1. Risk sharing contracts

A SC contract is a coordination mechanism to integrate SC partners and therefore benefit from improved operational performance. Supply chain contracts have been studied extensively in the context of traditional supply chains (Knoblich et al., 2015). Research suggests that SC contract analysis can improve both operational efficiency and SC coordination (Tang, 2006). Demand and pricing uncertainties are associated with many causes; For example, exchange rate movements, uncertainty of supply and demand, political turmoil, environmental influences and the changing risk preferences of consumers (Fotopoulos et al., 2008). Given such lack of visibility over future SC disruptions, risk-sharing contracts are one of the means of risk mitigation (Wakolbinger and Cruz, 2011). Uncertainties in demand and pricing, in particular, result in a situation where both buyer and supplier face the risk of shortages, delays and financial losses. Fang and Shou (2015) examine how levels of competitive intensity and supply uncertainty, affect the equilibrium decisions of order quantity and contract sharing. Risk sharing partnerships can lead to substantial benefits for the SC network (Buzacott and Peng, 2012). Given the difficulties of demand forecasting environments along with the problems of fluctuating prices of products in global markets, risk sharing contracts are increasingly expected to provide one form of trade-off solution for these demand and pricing uncertainties.

2.2. Buyer-Supplier power and dependence

Supply chain strategies must examine the role and contribution of long term partnerships among buyers and suppliers (Kirytopoulos et al., 2010). Buyer-supplier power and interdependence is central to any contractual agreement (Cox, 2002). There is an emerging agenda in the SCM literature that is focusing on power and dependence from a SC stakeholder's perspective (e.g. Caniels and Gelderman, 2007; Doran et al., 2005; Tomas et al., 2007; Sanders,

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2008; Karabati and Sayin, 2008; Kheljani et al., 2009; Liu et al., 2012). Strategic partnering is an increasingly widespread approach for buyers and suppliers (Blancero and Ellram, 1997). Porter's classic model (1985) supports the view that the buyers and suppliers will always try to gain as much advantage through their relationship. Kraljic's Portfolio Purchasing Model (1983) classified a firm's purchased intermediate products into four categories on the basis of the 'profit impact' (based on purchased quantity, percentage of total cost, impact on product quality and expected business growth) and supply risk (based on supplier availability, make-or-buy options and mitigating possibilities). In recent times, many adaptations and refinements to Kraljic's model have led to alternative portfolio models using other classifications/dimensions (Bensaou, 1999; Olsen and Ellram, 1997). However, there is a fundamental assumption underpinning all such portfolio models; the occurrence of differences in the power and dependency between a buyer and a supplier (Cox, 2002; Dubois and Pedersen, 2002).

Whilst such supply portfolio models suggest several SC strategies for every product category, the conditions determining the choice for a specific buying strategy has remained a research issue (Gelderman and Van Weele, 2003). Successive researchers have adapted Kraljic's purchasing portfolio model; for situational difficulty in purchasing (Olsen and Ellram, 1997), balancing power (Kumar, 1996) and supply risk (Doran et al., 2005). Dani et al. (2005) studied buyer-supplier behaviour in power and dependence scenarios to predict what will promote the highest level of dependency. Therefore, there is abundant evidence in extant literature on how purchasing strategies can be used to characterize the relationship between the various quadrants of combined Kraljic and Cox model (see Fig. 1) and the power-dependence balance in buyer-supplier coordination (Van Weele, 2000; Sacconi and Perona, 2007; Caniels and Gelderman, 2007).

3. Conceptual Development

In order to meet the objective of developing a model capable of representing a contract for mitigating the risks associated with demand fluctuation and price uncertainty. In order to build on how the literature review identified the way that the interconnectedness of globalised economic activity magnifies risks, it was necessary to select a sample case organization with recurrent global exposure. A leading automotive manufacturer with component suppliers distributed around the globe was identified as fulfilling the research design requirements. As

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the focal (hierarchical) firm in its automotive SC this organization also met the second objective of this research in terms of demonstrating and offering access to issues of power and dependency (a relational perspective on the dynamics of SC collaboration) stemming from its tiers of compliant suppliers. Thus the proposed analytical model for supply contract risk sharing includes a buyer-supplier relationship framework adapted from the literature and situational strength between stakeholders of the SC network (i.e. the focal firm and its globally distributed suppliers).

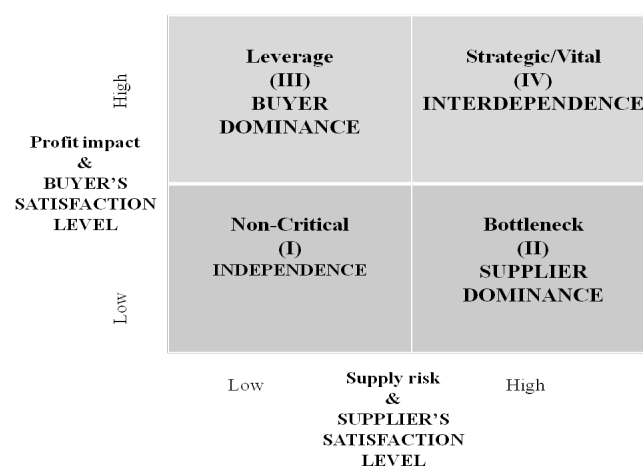


Fig. 1 Buyer-Supplier relationship framework
(Adapted from Kraljic, 1983 and Cox et al. 2002)

Cox et al. (2002) developed a framework for examining potential buyer supplier relationships based on relative utility of scarcity of resources. A buyer-supplier relationship is influenced by the importance of business relationships and the satisfaction of each party (Sinclair et al., 1996). Fig. 1 shows a buyer-supplier relationship framework adapted from Kraljic’s model combined with Cox’s model on buyer-supplier business relationship and satisfaction level. In the first quadrant, non-critical products demand efficient processing, product standardization, order variety and volume (Gelderman and Van Weele, 2003). They have relatively low financial value and purchasing risk. The buyer as well as supplier will independently satisfy their supply and demand requirements for such products. Due to the non-critical nature of the products, the buyer does not have to depend on one particular supplier. Similarly, a supplier satisfies the orders by market hedging on available volume and variety for his product. Leverage products can be outsourced from multiple suppliers. These products

account for a large share of the end product’s cost price with a relatively low supply risk (Caniels and Gelderman, 2007). For leverage products, the buyer has the edge over the supplier due to the easy availability of the product. A buyer in this quadrant meets quantity requirements by exploiting wide-spread availability through for instance tendering, target pricing and product substitution. Leverage products have low value (low supply risk) and are ordered frequently under a situation of buyer dominance. For bottleneck products, suppliers have the dominant power position due to the product having relatively low financial impact, but high supply risk. A buyer usually tries to ensure a constant supply by maintaining high stocks rather than providing quantity flexibility to the supplier. Due to supplier dominance in this quadrant, the buyer manages its inventory exposure through safety stock and product differentiation strategies. For the buyer, strategic components suggest the need for enhanced collaboration with the supplier due to high product value and high supply risk. It seems this interest in a long term relationship is reciprocal, as whilst a buyer needs quantity flexibility the supplier expects order commitment for the product, hence, both seek a long term relationship through contractual agreements. Risk sharing contracts play an important role in this quadrant of satisfaction and dominance level. As this forth quadrant is driven by interdependence it meets the objective of offering a context where mutuality is a prime objective and hence risk sharing contracts are relevant. Hence in this study a boundary is placed (limited to forth quadrant) by restricting the scope of this research to conditions where mutual buyer supplier dependency inform contracting for a new risk sharing supply chain contract to mitigate demand and price flexibility.

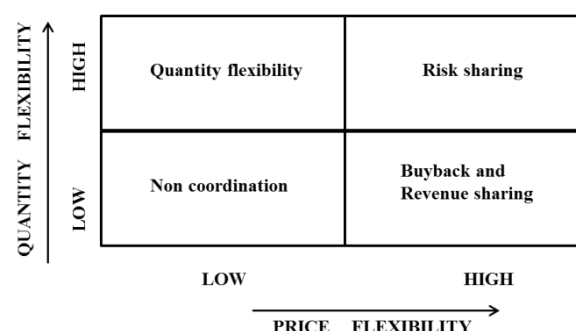


Fig. 2 Demand and price flexibility in supply chain: Contract perspective

The focal automotive manufacturing firm producing variety of truck models including Fork-lift trucks was selected to meet the study’s research design requirements. The firm

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employed a Quantity Flexibility (QF) contract to mitigate high demand uncertainty, but were faced with high procurement costs due to global economic fluctuations. In the QF contract, the supplier charges the buyer a fixed unit wholesale cost with a limited flexibility for adjusting his initial order quantity without any penalty (Shi and Chen, 2008). The QF contract is a coordination tool that provides an opportunity to the buyer to revise its initial order or forecast and specifies upper and lower bounds (usually as percentages of the initial order) on the final order quantity (Karakaya and Bakal, 2013). Knoblich et al. (2015) focussed on the concept of quantity flexibility in the context of different customer forecast demand behaviour. In this study, this fundamental concept of a QF contract is utilised to develop the risk sharing contract by incorporating a high price uncertainty parameter to the problem. As seen in Fig. 2, buyback and/or revenue sharing contracts are suitable for low price uncertainty to accommodate demand volatility. This becomes complex when price volatility is high for strategic components; then the supplier and buyer have to negotiate for the wholesale cost based on the ordering quantity with an option to adjust the demand. Price volatility driven by political instability, global sourcing and government sanctions has been found to significantly impact both stakeholders in the SC (Davarzani et al., 2015). The risk sharing contract will mitigate supply chain risks related to the combined effect of demand uncertainty and price volatility. In a QF, buyback or revenue sharing contract, the partners share some of the inventory and stock-out burden (Arshinder et al., 2007); the buyer is expected to make a commitment to reserve the order quantity based on the forecasted demand. In return, the supplier provides the buyer the flexibility to vary the ordered quantity within certain agreed limits (Wang and Tsao, 2006). A risk sharing contract is different to the QF contract as it incorporates not just quantity flexibility but also includes a price flexibility option (to mitigate price volatility); by negotiating the costs for the committed quantity through contract negotiation.

A risk sharing contract incorporates the price flexibility factor in terms of wholesale and penalty costs for ordering under or over the committed quantity. In this type of contract, two scenarios are expected where the buyer may increase or decrease the order quantity after observing expected or realized demand fluctuations. If only upward adjustment is allowed, then the buyer will place a conservative initial order by trying to ‘*transfer the risk*’ to the supplier by forcing him to maintain high inventory. This opportunistic behaviour of the buyer unwittingly tends to increase price volatility. On the other hand, if only downward adjustment is allowed, the buyer will make a generous initial order or make an aggressive commitment

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and try to 'avert the risk' of a demand shortage, leading to a bullwhip effect in the SC. Bidirectional adjustment contracts should be considered for supply chain performance (Wang and Tsao, 2006). Under the above two scenarios, the risk sharing contract is expected to provide the leverage to both the stakeholders by providing the most accurate demand without much fluctuation in procurement costs. This negotiated coordination can provide appropriate incentives to the buyer as well as the supplier by sharing the risk of demand uncertainty and price volatility.

4. Risk Sharing Contractual Model

4.1. Model development

Consider a buyer facing varying procurement costs over a finite horizon for strategic components required in product assembly. The global supplier at the same time is facing demand uncertainty due to the typical nature of industries where demand is variable and unpredictable. The objective of the risk sharing contract in such a case would be to provide a stable procurement cost for the buyer and a committed order quantity for the supplier. This can only be achieved by identifying an appropriate contract quantity for the SC profit maximization. The contract model hence negotiates for a contractual '*optimal quantity*' based on three distinct costs of the component namely quoted price, wholesale cost and penalty cost. The sensitivity of the model is dependent on two financial inputs, the wholesale cost for a minimum committed quantity and the penalty cost for not ordering the minimum committed quantity. Both these costs are based on the quoted price provided by the supplier. The model identifies the expected ordering quantity for the period by forecasting demand based on past orders. The negotiated contract costs i.e., wholesale cost and penalty cost are flexible and are determined based on the power and dependence relationship between buyer and supplier. Thus, the model is negotiated based on the quoted price provided by the supplier as a primary input parameter which later determines optimal quantity, wholesale cost and penalty cost for the contract. Demand predictability, physical efficiency and market responsiveness are important factors for supply chain management (Fisher, 1997). Assuming these conditions in a supply chain, the research examines decision making for the optimum contract quantity to balance risk between buyer and supplier. In the later part of this paper, we also study the implications of power and dependence on negotiated optimum quantity for the risk sharing contract.

4.2. Model formulation

The following assumptions are made before formulating the Integer Programming (IP) model for the risk sharing contract.

- The ordering cost and holding cost are assumed to be constant during contract negotiation.
- The contract quantity always lies between the minimum and maximum demand quantity anticipated by the buyer over the contract horizon.

Considering the above assumptions, the objective of the model is formulated to minimise the total purchase cost for the buyer and maximise the commitment quantity for the supplier. The decision variables used in the model are as follows:

Q_i = Forecasted demand quantity for i^{th} period in the contract horizon

Q_{\min} = Minimum expected demand in a contract horizon

Q_{\max} = Maximum expected demand in contract horizon

C_e = Quoted price provided by the supplier

C_q = Negotiated wholesale cost for contract quantity

C_n = Negotiated penalty cost for under-ordered quantity

α = Ratio of negotiated wholesale cost to quoted price

β = Ratio of negotiated penalty cost to quoted price

Q = Negotiated initial order quantity

The range for quantity variation is decided by the buyer and supplier based on Q_{\min} and Q_{\max} predicted from the forecasted demand for the contract horizon. The flexibility option is utilised by the buyer by signing a contract for Q units with the flexibility to change the initial order Q to actual order of q units by a factor μ , such that $(1 - \mu) Q < q < (1 + \mu) Q$. The objective function for minimizing total purchase cost, Z for optimal commitment quantity Q^* is formulated as IP model is given below:

$$Z = \sum_{i=1}^{12} \{x_i [Q * C_q + (Q_i - Q) * C_e] + y_i [Q_i * C_q + (Q - Q_i) * C_n]\} \quad (4.1)$$

$$Q_{\min} \leq Q_i \leq Q_{\max} \quad (4.2)$$

$$C_q = \alpha * C_e \quad (4.3)$$

$$C_n = \beta * C_e \quad (4.4)$$

$$\alpha = f(Q) \quad (4.5)$$

$$\beta = f(Q) \quad (4.6)$$

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$$x_i = \begin{cases} 1, & \text{if } Q_i > Q \\ 0, & \text{otherwise} \end{cases} \quad (4.7)$$

$$y_i = \begin{cases} 1, & \text{if } Q_i < Q \\ 0, & \text{otherwise} \end{cases} \quad (4.8)$$

$$x_i + y_i = 1; \quad x_i, y_i \in (0,1) \quad (4.9)$$

$$Q, C_q, C_n \geq 0 \quad (4.10)$$

In the objective function (equation 4.1) we consider a yearly contract. There will be either over ordering or under ordering by the buyer with respect to the committed ‘contract quantity’ for every i^{th} period (month). The first section in equation 4.1 considers the purchase cost for the over ordered quantity for i^{th} period where the equation applies appropriate wholesale cost for contract quantity and a quoted price for units more than contract quantity. Similarly, the second part considers the under ordered purchase cost for i^{th} period where the under ordered quantity is still purchased at wholesale cost with an additional penalty for the unordered quantity. For every i^{th} period, either of the two will be possible and binary function (equation 4.7, 4.8, 4.9) caters to this requirement along with other supporting constraints for non-negativity requirements (equation 4.10). Summation of purchase cost for i periods provides the minimum total purchase cost for the contract horizon by solving IP problem for optimal contract quantity Q^* . The contract horizon is considered to be a 12-month period for modelling purpose but can be varied on the basis of the nature and dependability of the industry. The above mathematical formulation provides an optimal solution for both the stakeholders through contract negotiation influenced by power and dependence.

5. Analysis and Findings

The focal automotive manufacturing company producing Fork-lift trucks, with a global supply base selected for testing the developed model was aware of the problems they had faced during implementation of an earlier QF contract. Sourcing from global suppliers for vital components led to exposure to risks primarily associated with heavy price fluctuations and supply (as well as demand) uncertainty. Case company SC managers were approached to study their strategic outsourcing activity; data was then collected from primary sources of information like purchase orders, archival documents, internal presentations and other official purchase documents. After collecting relevant data, the analysis was conducted by testing the proposed contract model in two parts. Initially, forecasting techniques were used to predict the

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expected demand quantity for future contract horizons and secondly, this forecasted data was utilized for identifying the optimal quantity for a risk sharing contract.

5.1. Demand forecasting

Demand forecasting plays an important role in managing supply chains due to uncertainty in the demand (Gunasekaran and Ngai, 2009). Different forecasting methods are discussed in the literature to predict the demand quantity (Miyaoka and Kopczak, 2000; Chen, 2000). The most commonly used approach for periodic forecasting is the Holt–Winters exponential smoothing approach. The demand for the next rolling horizon is forecast based on demand observed in the previous horizon. The Holt-Winters model used in this section of the study is based on three smoothing factors- level, trend and seasonality (Winters, 1960).

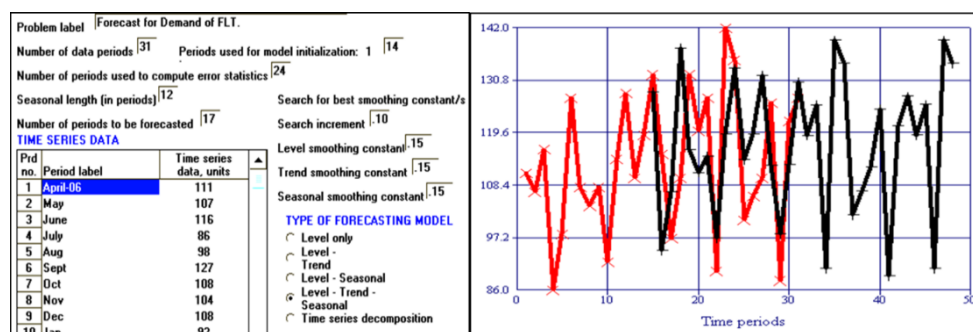


Fig. 3 Time Series demand forecasting for periods in contract horizon

Past 3-year demand data provided by the company was fed into the forecasting model. Fig. 3 shows the overlapping of actual demand data with the forecasted data in the central region of the graph. This is to check the validity of the forecasted data. Accuracy of the forecast is checked using ‘tracking signal’ value and it is found to be 0.147, which is comparatively very small and within the acceptable limits for an accurate forecast, since the maximum limit for acceptability of forecasted value is 4 (Jacobs et al., 2010). The forecasted vs. actual demand overlaps providing confidence in the anticipated demand quantity for the contract horizon. The forecasted demand data is now ready for being utilized in the contract model to find the optimum quantity in a contract horizon.

5.2. Solution and Comparison

The IP problem was formulated and solved in a widely used commercial optimization solver –LINGO as shown in Fig. 4. Two different dimensions were considered to capture the intricacies related to buyer-supplier power and dependence on the proposed risk sharing contract model. Two cases are typically observed during any contract negotiations and would provide us with insights into the associated situational strength. While negotiating the contract, buyer and supplier may consider the cost of the component to be independent of the contract quantity commitment. Hence in case 1, we analyse the model with an assumption that the buyer and supplier are negotiating the wholesale and penalty costs independent of the quantity commitment (α and $\beta \neq f(Q)$). In case 2, the wholesale and penalty costs are negotiated based on the committed quantity ordered (α and $\beta = f(Q)$).

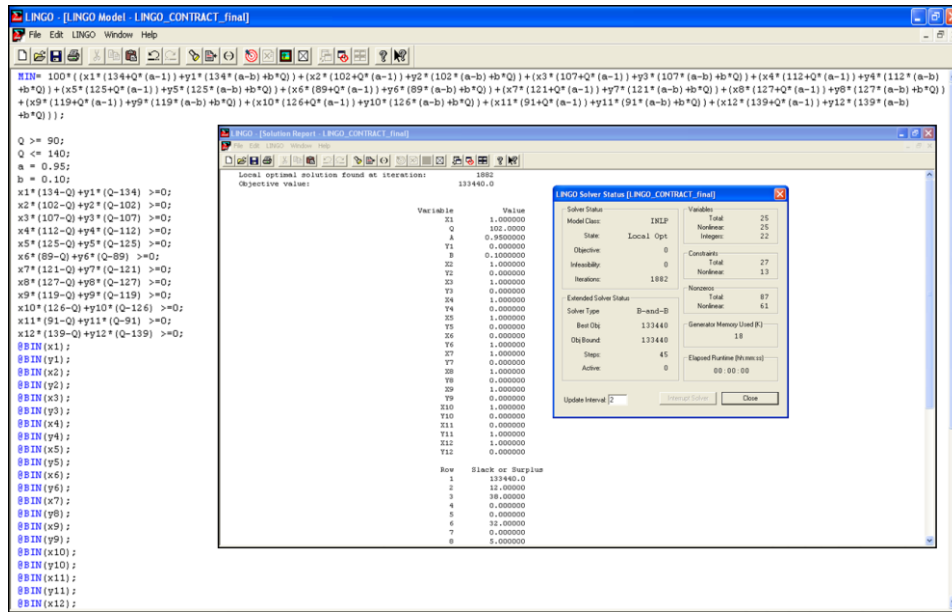


Fig. 4 Snapshot: IP formulation in optimization solver

Case 1: α and β independent of quantity ordered. $\{\alpha \text{ and } \beta \neq f(Q)\}$

Here, wholesale cost and penalty cost are assumed to be independent of the quantity ordered and analysed for the results. Since the ordering quantity is calculated by varying α ($0.75 \leq \alpha \leq 1$) and β ($0 \leq \beta \leq 0.25$) independently, 25 different combinations of α and β provide several optimal quantity solutions as seen in Fig. 5. It is observed that the lower wholesale cost (α) is expected to provide the supplier with highest committed contract (optimal) quantity. Similarly, when we compare the total purchase cost with respect to these

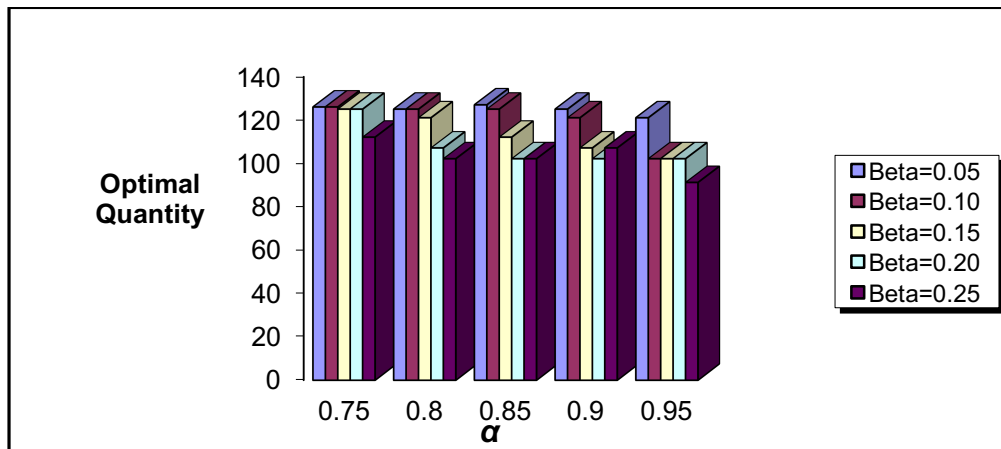


Fig. 5 Optimal Quantity for various combinations of α and β

different combinations of α and β ; it is observed that, the buyer can actually minimise total purchase cost by committing for a higher contract quantity as seen in Fig. 6. In such a case, the buyer may over-order the quantity leading to a bullwhip effect, but this essentially shares the risk of the price volatility. On the other side, higher commitment of quantity shares the risk of demand fluctuation for the supplier. The overall effect of change in total purchase cost for lower values of α and for all values of β is significantly less and is beneficial for the buyer as well as the supplier. The quoted price paid for ordering more than the contract quantity is not influenced by the penalty cost paid for ordering less than the contract quantity, which is yet another significant finding. This also infers that the wholesale cost plays a major role in any contract negotiation, even if the penalty cost is associated in the contract.

The dividing line shown in Fig. 6 shows the dominating scenarios for two prominent stakeholders in purchasing commonly observed in forth quadrant (Fig. 1). This also provides buyer and supplier with their optimal contract zones for executing risk sharing supply chain contracts. The left half (in Fig. 6) is dominated by supplier power as it tries to bring down the wholesale cost to minimise their purchase cost, whereas the right half is dominated by buyer power trying to maximise their own profit by achieving a higher commitment quantity. This is a commonly observed phenomenon in SCM when demand is certain and independent of cost.

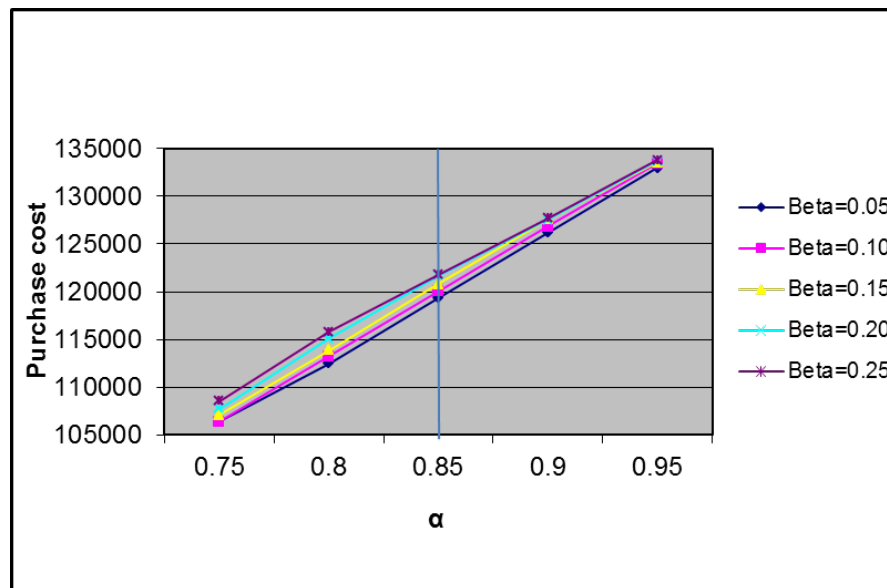


Fig. 6 Purchase cost versus α for varying β

Case 2: When α and β are dependent on quantity ordered $\{\alpha \text{ and } \beta = f(Q)\}$.

In this case α and β are considered to be dependent on the committed quantity. This is a typical scenario where the negotiations are purely based on average order quantity (i.e. higher the average quantity order higher the wholesale price). The quantity ordered Q is evaluated by varying α ($1 \geq \alpha \geq 0.75$) and β ($0 \leq \beta \leq 0.25$) values to suit best combinations for the optimal quantity. The model predicts local optimal solutions for different combinations of α and β . The local optimal solutions obtained for the case studied are presented in Table 1.

Table 1. Local optimal solutions when α and $\beta = f(Q)$

Wholesale price factor, α	Penalty cost factor, β	Purchase cost, Z	Order Quantity, Q^*
0.91	0.112	128552.8	112
0.87	0.07	123315.2	121
0.85	0.05	119664.8	127
0.8	0	111360.0	140

Table 1 show four different local optimal solutions obtained for the contract quantity. The values presented above are specific to the test model and could vary from contract to

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contract. Nevertheless, the results give a transparent view of optimum quantity with total purchase cost for best combinations of α and β . For a buyer this helps in understanding the best possible wholesale price and penalty cost combination within a specific demand range. Here the global optimum solution is not obtained as this can be achieved by paying the lowest possible wholesale cost without any penalty cost for the contract quantity. But, this is possible only in the third quadrant where the buyer is dominant during contract negotiations. The supplier would ask for the maximum commitment quantity at the quoted price, if the supplier were dominant in this quadrant. The impact of quantity ordered on negotiated costs is an important consideration for the contract negotiation as it provides both stakeholders with best combination of α and β , unlike two distinctive operability zones as in case I.

6. Conclusion

The research proposes a risk sharing contract to distribute the risk of demand uncertainty and price volatility among different SC stakeholders. The situational strength evaluated under buyer-supplier power and dependence following two cases illuminates the inherent complexity in contracting. The research develops a risk sharing contract in a SC environment ideal for studying strategic/vital components exposed to the combined risk of demand uncertainty and price volatility. The proposed contract provides directions for building long term supply chain contracts for mitigating known as well as unknown risks. The model would be suited to industries such as automobile, aerospace, electronics and computer manufacturing where product costs are high, components are sourced globally and there is highly uncertain demand due to increased competition. Although the scope of research was limited to the fourth quadrant of the buyer-supplier relationship framework, the contract is believed to be beneficial for any satisfaction and dependence level in the matrix. The risk sharing contract model proposed here contributes to a potentially novel perspective on existing theory in buyer-supplier power and dependence by providing a relational perspective on the dynamics of supply chain design and collaboration. The developed relationship framework and risk sharing contract model are expected to help SC managers in better understanding behavioural aspects during contract negotiations. This study may also encourage the SCRM community to consider similar strategic contracts as a possible long term risk mitigation strategy. Increasing inter-dependence through the development of strategic alliances with SC partners is necessary due to the increased uncertainties and risks of a globalised business world.

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A risk sharing contract is one such robust risk mitigation strategy for long-term profitability in SCM.

The SC contract model is validated through a single case company. Hence, further research is necessary to check the robustness of the model by testing it across different industry setting. Buyer-supplier relationships captured in the paper is limited and further research into the bounded rationality in SC risk sharing contracts is needed. The future supply chains are expected to be driven by the sustainability concerns (Wilhelm et al., 2016; Montabon et al., 2016). The research should address the role risk sharing contracts can play specifically in meeting sustainability concerns, e.g. with social (co-ordination), economic (network profitability) and environmental (inventory obsolesce) parameters.

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